PATENT

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Applicants: Jang-Kun Song, et al. Examiner: Rude, Timothy L.

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For: **VERTICALLY ALIGNED MODE LIQUID CRYSTAL DISPLAY WITH DIFFERENTIATED B CELL CAP**

Commissioner for Patents
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DECLARATION UNDER 37 C.F.R 1.132

I, Seung-Hee LEE, in my capacity as an applicant and co-inventor of the subject matter of the above-referenced patent application, hereby declare as follows:

I have been employed by Samsung Electronics Co., Ltd. (Samsung), Suwon-city, Korea, the assignee of the above-referenced patent application for the last 6 years. During my employment with Samsung, my work has been directed, in general, to research and development of liquid crystal Modes in the field of liquid crystal displays. My current position at **SAMSUNG ELECTRONICS CO., LTD.**, is as Senior Engineer for the IP & External Affairs Team, LCD R&D Center, LCD Business, and I have been at this position since 2000.

I have a Physical Science Master's degree in Quantum Physics from Korea University, and a Physical Science Bachelor's degree in Quantum Physics also from Korea University.

I have extensive knowledge and experience with regard to liquid crystal Mode res earch in the field of liquid crystal displays and have over three publications covering dive rse aspects in such areas of research.

This Declaration is respectfully submitted in support of our contention that combining differentiation of cell gaps among the red, green, and blue pixels with pixel and common electrodes with opening patterns, as described in our specification, produces a synergistic effect that is neither taught nor suggested in the combination of Kim and Takao or Kim and Ogawa. I am fully familiar with the subject matter of the above-referenced application and I have reviewed the cited patent references Kim, Takao, and Ogawa.

It is my belief that there is no motivation or suggestion in Kim, Takao, or Ogawa to combine Kim and Takao or Kim and Ogawa to produce a liquid crystal display *wherein a B cell gap is differentiated from an R cell gap or a G cell gap; the R cell gap indicates the thickness of the liquid crystal layer at the region of the red color filter, the G cell gap indicates the thickness of the liquid crystal layer at the region of the green color filter and the B cell gap indicates the thickness of the liquid crystal layer at the region of the blue color filter, wherein the B cell gap, the R cell gap and the G cell gap are differentiated from each other by: R cell gap – G cell gap < G cell gap – B cell gap, and wherein the first and the second opening patterns partition the pixel region into a plurality of micro-domains*, as essentially claimed in Claims 1 and 9. In other words, I believe that these patent references do not disclose or suggest a liquid crystal display

having a B cell gap, a G cell gap, and an R cell gap that are differentiated from each other by R cell gap – G cell gap < G cell gap – B cell gap and having a pixel region partitioned into a plurality of micro-domains by the first and second opening patterns.

As explained in our specification, in a vertically aligned (VA) liquid crystal display having a wide viewing angle, the light transmission-voltage curve varies with wavelength, causing an inter-gray scale color shift, in turn causing a white light to appear yellowish. This difference in transmissions is illustrated in FIGS. 9 and 10, which plot differences in light transmission of 450nm and 600nm light as a function of increasing $\Delta n\%d$, where Δn is the diffraction anisotropy of the liquid crystal and d is the thickness of the liquid crystal layer. As can be seen from the figures, there is a more severe gray scale color shift in VA mode than in twisted nematic (TN) mode. In particular, the B color exhibits a high light transmission at lower gray scales, while the transmission of R and G colors is heightened at higher gray scales. The dependence of light transmission on wavelength is also illustrated by equations (1) and (2) for TN and VA modes, respectively.

This inter-gray scale color shift can be reduced by differentiating the RGB cell gaps. Since the maximum value of Δn in a liquid crystal display is 0.08, one would want to maximize light transmissions for Δn=0.08, which implies optimal cell gaps of 4.06μm, 3.44μm, and 2.81μm, for R, G, and B, respectively, for a R-B cell gap of 1.25μm. The graph of FIG. 11 illustrates that an R-B cell gap difference of about 1.25μm can eradicate the inter-gray scale color shift. FIGS. 12(a)-(c) depict the shape of V-T curves for R, G, and B for varying cell gap values. The V-T curves for different B cell gap values shows

the greatest variation, and these curves peak and flatten out for cell gaps greater than about 4μm. However, it is difficult to manufacture such a cell gap by controlling color filter thickness, due to difficulties in maintaining uniformity in cell gaps.

Analysis of the V-T graphs of FIGS. 12(a)-(c) shows that a small cell gap difference of the B color, less than the theoretical gap difference of 1.25μm, can induce a considerable reduction of the color shift. However, in a patterned vertically aligned (PVA) mode where an opening pattern is present, the electric field is weaker in the opening region than in the non-opening region, and the effective value of $\Delta n\%d$ of the liquid crystal is small. Thus, over the entire pixel structure, the V-T curve of a PVA mode is smoothly elevated as compared to the V-T curve for a VA or TN mode lacking the opening pattern. This is illustrated in FIG. 13, which depicts the V-T curve of a multi-domain structure with an opening pattern to that of a single domain structure. The use of a PVA mode with an opening pattern has an effect of self-correcting the color shift, and a cell gap difference much less than the theoretical difference of 1.25μm can significantly reduce color shift.

FIGS. 14 and 15 show that the inter-gray scale color shift can be significantly reduced even when the B cell gap is smaller than the R-cell or G-cell gaps by only 0.2 to 0.3μm. Variation in the B cell gap is an important determinant of the color shift, but for PVA mode, the color shift is corrected by the opening pattern. The graph of FIG. 17 illustrates that a B cell gap of 0.2!0.15μm can both significantly reduce the color shift and provide processing efficiency and yield. Thus, use of a PVA mode liquid crystal with an

opening pattern, due to its color shift correcting properties, enables the use B cell gaps much smaller than those predicted by a theoretical analysis of the VA mode light transmission-wavelength relationship. The reduced B cell gaps reduce the inter-gray scale color shift, resulting in improved picture quality.

Kim concerns a multi-domain liquid crystal device, while Takao is concerned with a ferroelectric liquid crystal display device with differing thicknesses for the R, G, and B filters. However, there is no disclosure or suggestion in Kim and Takao of combining a PVA mode liquid crystal with an opening pattern with a reduced B cell gap to correct an inter-gray scale color shift. Ogawa concerns color correction in a TN mode liquid crystal display device. However, once again there is no disclosure or suggestion in Kim and Ogawa of combining a PVA mode liquid crystal with a reduced B cell gap to correct an inter-gray scale color shift.

Accordingly, our specification provides evidence of unexpected and synergistic advantageous properties achieved by Applicant's claimed combination *wherein a B cell gap is differentiated from an R cell gap or a G cell gap, . . . wherein the B cell gap, the R cell gap and the G cell gap are differentiated from each other by: R cell gap – G cell gap < G cell gap – B cell gap, and wherein the first and the second opening patterns partition the pixel region into a plurality of micro-domains.*

In summary, based on the above, it is readily apparent to one of ordinary skill in the art that neither Kim and Takao nor Kim and Ogawa disclose or suggest the synergistic effect achieved by combining differentiation of cell gaps among the red, green, and blue

pixels with a PVA mode liquid crystal having pixel and common electrodes with opening patterns.

I hereby declare that all statements made herein are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are made punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or of any patents issuing therefrom.

Dated: December 15, 2005

Signed: _____

Seung-Hee LEE